RSVP Extinction Meeting
8 December 2004
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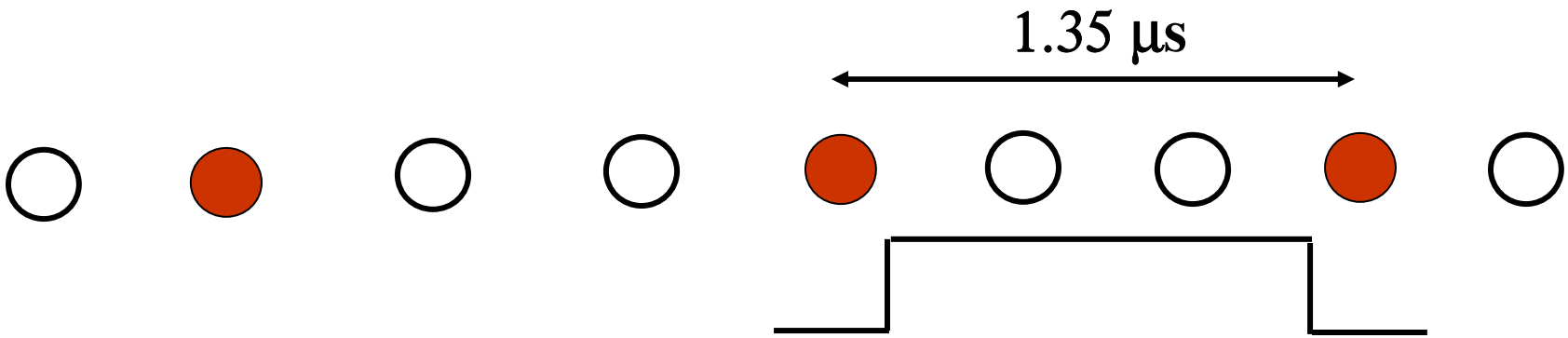
BNL

MECO beam structure:



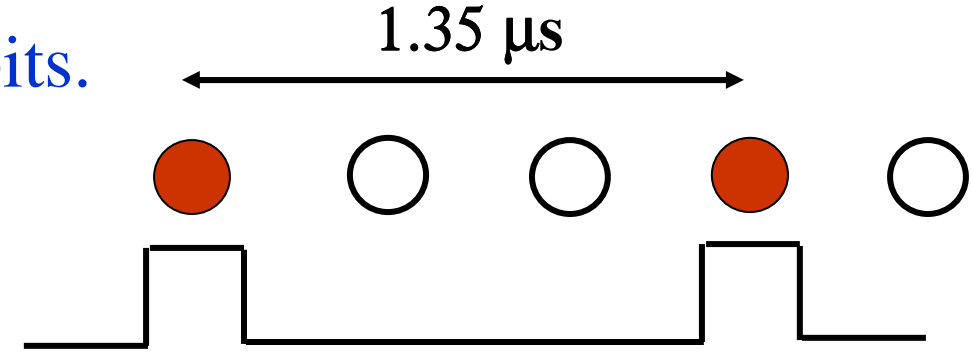
- **Need Extinction to 10^{-9}**
- **Measure it to 10%**

What is Planned for the AGS Ring

Mike Brennan (1998)

- Use a 60KHz AC Dipole Magnet (CW). Resonance at the vertical betatron frequency

- Use a pulsed Strip-line kicker to kick the full buckets into stable orbits.

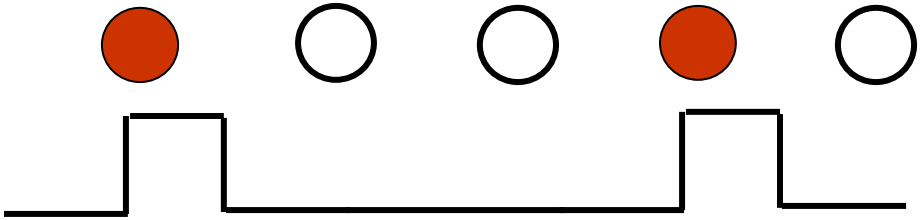


- Need 1-50ms to drive particles off (driven by the strip-line kicker)

Beam on Resonance is Lost!

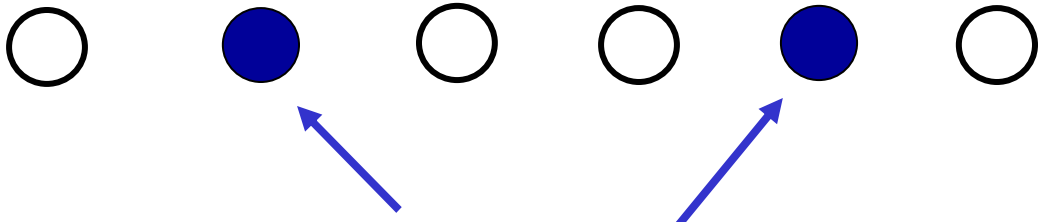
Unless…

- AC dipole magnet drifts in amplitude/frequency
- The strip-line kicker malfunctions



- The vertical tune frequency drifts/dispersion

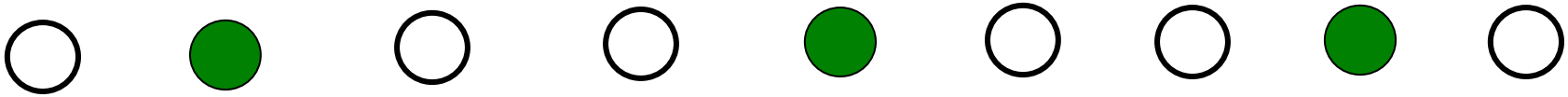
•In AGS ring only two filled buckets:



20TP in each filled bucket (FB)

<40K Protons everywhere else (EB)

•At extraction: 100MP in each filled bucket (FB)



<0.1P in each empty bucket (EB)

Is it Possible to Measure Extinction in AGS Ring?

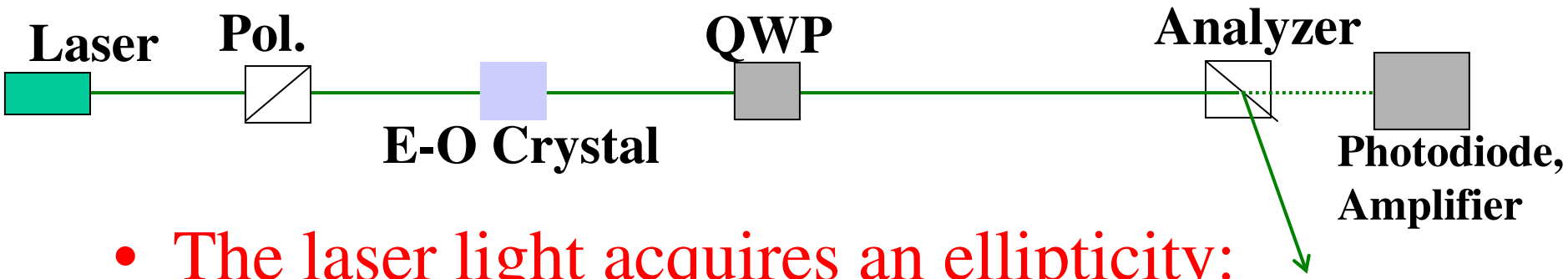
- The electric field due to the beam at 1cm away, assuming the beam size < 1cm:

$$E = \frac{Q/L}{2\pi\varepsilon_0 r}$$

- For filled buckets: Q=*20*TP, $L \cong$100ns×c=30m

$$E = \frac{\left(2\times10^{13}\, p\times1.6\times10^{-19}\,\mathrm{c}/\,p\right)/\left(100\mathrm{ns}\times3\times10^{8}\,\mathrm{m/s}\right)}{2\pi\times8.85\times10^{-12}\,\mathrm{F/m}\times10^{-2}\,\mathrm{m}} \Rightarrow E\approx 0.2\mathrm{MV/m}$$

Electro-optic Effect



- The laser light acquires an ellipticity:

$$\Gamma(t) = \frac{2\pi}{\lambda}\Delta n(t) \times l$$

$$\Delta n(t) = \frac{1}{2}\left(n_e^3 r_{33} - n_o^3 r_{13}\right) \times E_c(t)$$

For $LiNbO_3$ Crystal:

$$n_e = 2.239$$

$$n_o = 2.337$$

$$r_{13} = 7.7\, pm/V$$

$$r_{33} = 28.8\, pm/V$$

Dielectric constant: ε≈25

$$E_c = \frac{E}{\varepsilon} \approx \frac{0.2\text{MV/m}}{25} \approx 0.01\text{MV/m} \Rightarrow E_c \approx 10\text{KV/m}$$

$\mapsto \Gamma(t) \approx 70\text{mrad}$, for $l = 1\text{cm}$ long crystal and

λ=1μm laser wavelength

$$\text{SNR} = \Gamma(t)\sqrt{\frac{PTq}{2\hbar\omega}} = 70\text{mrad}\sqrt{\frac{0.1\text{W}\times 100\text{ns}\times 0.8}{2\times 1.6\times 10^{-19}\,\text{J}}}$$

$$\Rightarrow \text{SNR} \approx 10,000$$

For 10^{-9}extinction and 100ns→1.3μs:

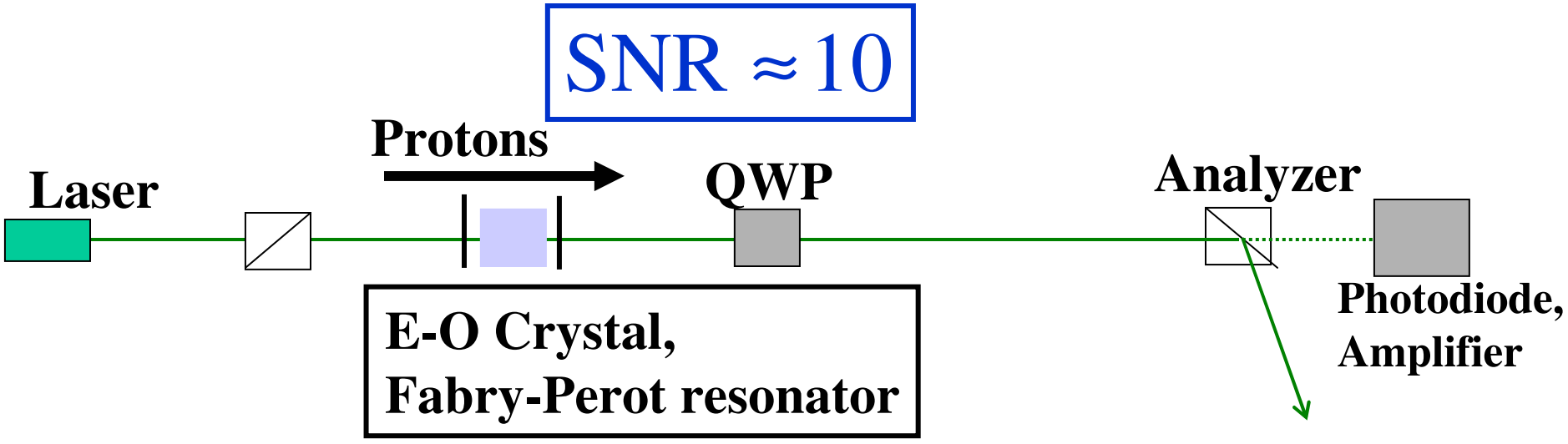
$$\text{SNR} \approx 3\times 10^{-5}$$

With 400,000 passes/AGS cycle in 0.5s:

$$\boxed{\text{SNR} \approx 2\times 10^{-2}}$$

Proposal to use Fabry-Perot

resonator with 500 reflections, 2cm long (corresponding to 10m, less than the 30m of the beam base length):



Dynamic range

- Main signal: 35rad! (filled bucket)
- Extinction: 35nrad (empty buckets),
- i.e. dynamic range of 3×10^7

- The best way to achieve the dynamic range is to use a light switch after the analyzer to gain three to four orders of magnitude.

Cost and Schedule

- Laser: $30K
- Optical elements: $20K
- Post doc, 1year: $80K
- Tech.: $20K
- Interface with AGS: ?

- Total: $150K+AGS interface
- 1 year development.

Summary

- We have presented a way to measure the extinction in the AGS ring the required extinction of 10^{-9} to 10% within a single AGS cycle!
- It cannot be done in the extraction beamline

- Lab development
- Installation in ring
- Measurement
- Total cost: $150K+AGS interface and 1year development total.